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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T580**(E)**(J28)T
AUGUST EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

28 July 2014 (Y-Paper)
13:00–16:00

This question paper consists of 6 pages, 1 diagram sheet and 1 formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N4
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Subsections of questions should be kept together.
5. Rule off across the page on completion of each section.
6. ALL formulae should be shown in the answers.
7. Show ALL calculations.
8. Answers should be in BLUE or BLACK ink.
9. ALL diagrams should be in pencil.
10. ALL the answers must be rounded off to THREE decimal places.
11. Take $g = 9{,}8\ m/s^2$.
12. Write neatly and legibly.

QUESTION 1

1.1 A ship cruises at 12 km/h in still waters and sets course due south west. It is driven off course by a current flowing W 15° N at a rate of 4 km/h.

1.1.1 Draw a neat vector diagram to represent the information. Include the resultant in the diagram. (2)

1.1.2 Calculate the magnitude and direction of the resultant velocity. (3)

1.2 A projectile is launched at an angle of 30° with the horizontal, with a velocity of 125 m/s.

Calculate the following:

1.2.1 The time taken for the projectile to hit a target at ground level on the same horizontal plane (2)

1.2.2 The maximum range that a projectile of this kind can reach (1)

1.2.3 The height reached by the projectile above the horizontal after travelling for 5 seconds (2)

1.3 Ship A sails at 30 km/h north 48° west, whilst ship B is sailing at 20 km/h south 15° east.

1.3.1 Draw a neat vector diagram and show clearly the vector representing the velocity of ship A relative to ship B. (3)

1.3.2 Calculate the velocity of ship A relative to ship B in magnitude and direction. (2)

[15]

QUESTION 2

2.1 Define the term *radian*. (1)

2.2 Draw a sketch to show what is meant by your answer in QUESTION 2.1. (1)

2.3 The minutes indicator of a tower clock is 1,2 m long and takes 20 minutes to move from the 12 numeral to the 4 numeral.

Calculate the following:

2.3.1 The angular displacement of the indicator in degrees and in radians (2)

2.3.2 The linear displacement of the tip of the indicator (2)

2.3.3 The angular velocity of the indicator (2)

2.3.4 The linear velocity of the tip of the indicator (2)

[10]

QUESTION 3

3.1 Define *Newton's second law.* (1)

3.2 The engine of a motor car with a mass of 900 kg is switched off while moving at 60 km/h on a downhill with a slope of 1 in 15. The resistance to motion is 200 N. At the end of the downhill the motor car travels at 90 km/h.

Calculate the following:

3.2.1 The weight component parallel to the plane (2)

3.2.2 The acceleration force (2)

3.2.3 The acceleration (2)

3.2.4 The length of the downhill when 90 km/h is reached (2)

3.2.5 The potential energy lost (2)
[11]

QUESTION 4

4.1 Define *bending moment* of a beam. (2)

4.2 In FIGURE 1 on the DIAGRAM SHEET (attached), the beam is in equilibrium and loaded as indicated in the sketch.

The shear-force diagram is also given. (Not according to scale.) Support A = 21,455 kN and D = 31,545 kN.

4.2.1 Determine the position and magnitude of the maximum bending moment. (3)

4.2.2 Draw the bending moment diagram according to a suitable scale, showing ALL the main values. (4)

4.3 Refer to FIGURE 2 on the DIAGRAM SHEET (attached) and determine the position of the centre of gravity, from point A. (5)
[14]

QUESTION 5

5.1 Define *Pascals' law.* (2)

5.2 The ram of a hydraulic press is 100 mm in diameter. The diameter and stroke of the plunger are 20 mm and 50 mm respectively. The mechanical advantage is 16.

Calculate the following:

5.2.1 The force to be applied to the lever to lift a load of 2,3 Mg, when the efficiency is 85% (5)

5.2.2 The actual volume of liquid delivered to the ram after 5 strokes if the slip is 5% (3)

5.2.3 The distance moved by the ram (in mm) after 5 strokes (2)

5.3 The following details refer to a single-cylinder water pump:

Static height	=	18 m
Area of plunger	=	$17{,}671 \times 10^{-3}$ m²
Stroke length	=	300 mm
Rotational frequency of the pump	=	100 r/min

Calculate the following:

5.3.1 The volume of water delivered per second (2)

5.3.2 The force per second on the piston (2)

5.3.3 The theoretical power of the pump (2)

5.4 Explain the function of a hydraulic accumulator. (2)

[20]

QUESTION 6

6.1 Define *Hooke's law.* (2)

6.2 The following results were obtained in a tensile test on a mild steel specimen 20 mm wide and 10 mm thick. The length is 200 mm.

Load (kN)	16	32	48	64
Extension (mm)	0,066	0,133	0,198	0,264

6.2.1 Draw up a table of stress (MPa) against strain. (2)

6.2.2 Draw the stress-strain graph. (3)

6.2.3 Determine Young's modulus from the graph. (2)

6.3 The ends of a copper rod with a cross-sectional area of 1,3 cm^2 are held rigidly between two fixed points at a temperature of 30 °C. Young's modulus for copper is 1,28 x 10^{11} Pa. The coefficient of linear expansion for copper is 17 x 10^{-6}/K.

Calculate the tensile force in the rod when the temperature drops to 20 °C. (5)
[14]

QUESTION 7

7.1 Consider Charles' law and answer the following questions:

7.1.1 Define *Charles' law*. (3)

7.1.2 Draw a typical graph, representing Charles' law. (2)

7.1.3 Write a formula, representing Charles' law. (1)

7.2 The size of a rectangular swimming pool is 10 m x 6 m x 1,8 m deep. The pool is filled with water at 25 °C to within 5 mm of the overflow of the pool. The volumetric expansion of water is 207 x 10^{-6}/K.

Calculate the temperature at which the pool will start to overflow if the expansion of the swimming pool, as well as evaporation, is ignored. (4)

7.3 A 1 m^3 cylinder containing air at 25 °C and 500 kPa, is connected by means of a valve to another cylinder containing 5 kg of air at 35 °C and 200 kPa. The valve is opened and the entire system is allowed to reach thermal equilibrium with the surroundings at 20 °C.

The gas constant for the air is 287 J/kg.K.

Calculate the following:

7.3.1 The volume of the second cylinder (2)

7.3.2 The final equilibrium pressure (4)
[16]

TOTAL: 100

DIAGRAM SHEET

QUESTION 4.2

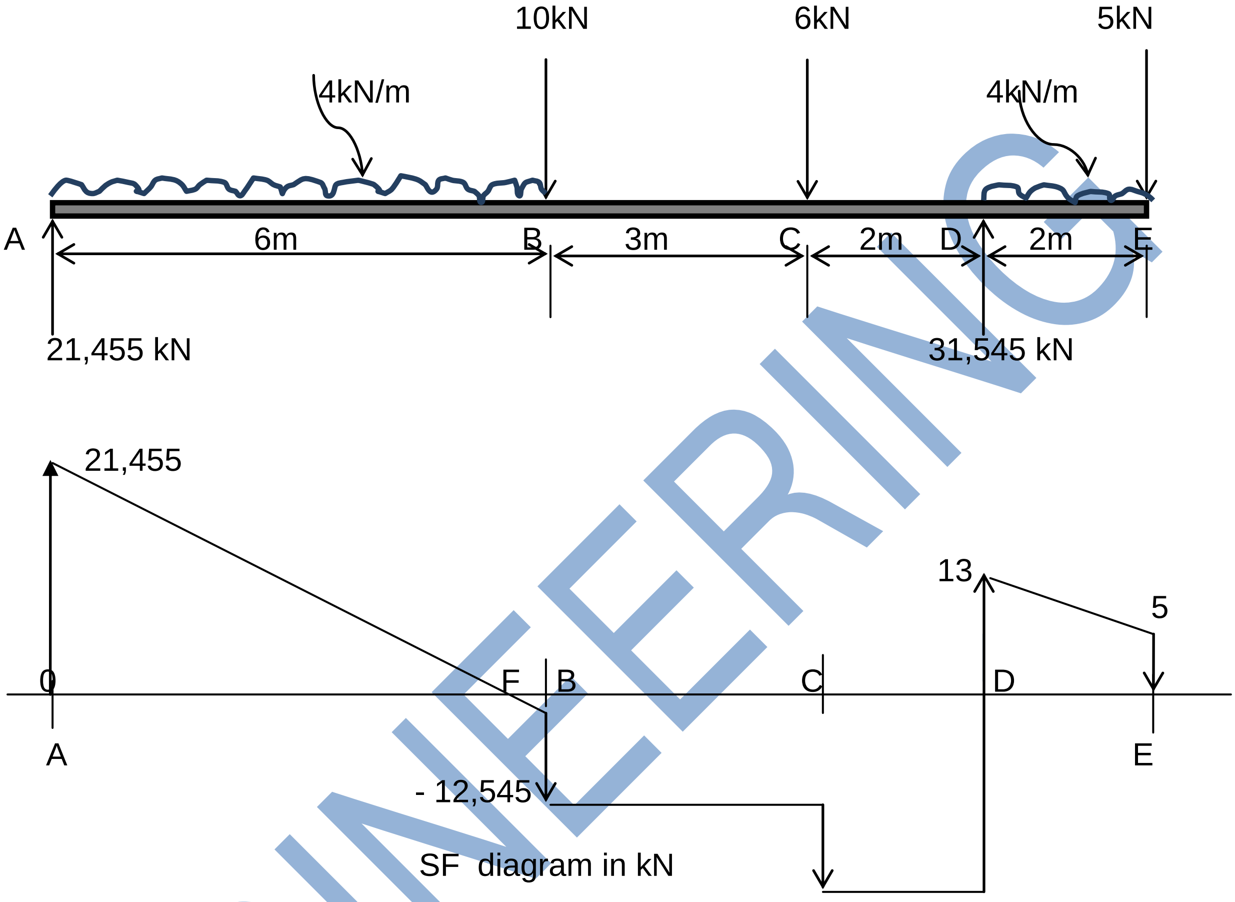

FIGURE 1

QUESTION 4.3

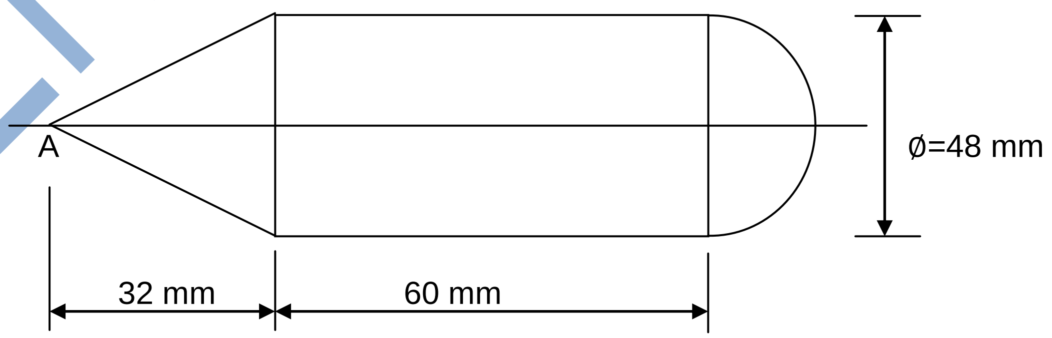

FIGURE 2

FORMULA SHEET

Any applicable formula may also be used.

$S = \frac{u+v}{2} \times t$

$\overline{V} = \frac{s}{t}$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$v_g = \frac{u+v}{2}$

$\omega = 2\pi N$

$\omega = \frac{\theta}{t}$

$\theta = \frac{\omega_2 + \omega_1}{2} \times t$

$\omega_2 = \omega_1 + \alpha t$

$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$v = \omega R$

$\theta = 2\pi n$

$S = R\theta$

$\alpha = \frac{\omega_2^2 - \omega_1^2}{2\theta}$

$a = \alpha R$

$v = \pi DN$

$T = FR$

$AV = T\theta = WD$

$P = 2\pi NT$

$P = Fv$

$P = T\omega$

$F_a = ma$

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

$P = \frac{F}{A}$

$m = \rho \times vol$

$P = \rho gh$

$\frac{W_r}{F_p} = \frac{D^2}{d^2}$

$W.D. = P \times V = A.V.$

$H.V. = \frac{F_p}{F_h} = M.A.$

$AV = mgh = WD$

$Q = mc\Delta t$

$\Delta l = l_o \alpha \Delta t$

$\beta = 2\alpha$

$\gamma = 3\alpha$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$PV = mRT$

$\in = \frac{x}{l}$

$E = \frac{\sigma}{\in}$

$\sigma = \frac{F}{A}$

$E = \frac{Fl}{Ax}$

$\overline{y} = \frac{A_1y_1 \pm A_2y_2 \ldots}{A_1 \pm A_2 \ldots}$

$\overline{y} = \frac{v_1y_1 \pm v_2y_2 \ldots}{v_1 \pm v_2 \ldots}$